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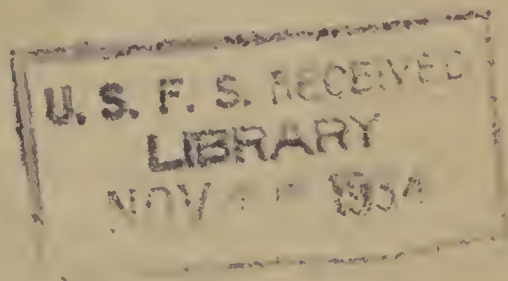
FOREST RANGES AND A FOREST RANGE PROGRAM

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FOREST RANGES

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FORAGE—AN IMPORTANT FOREST LAND RESOURCE

The forage produced by herbaceous and shrubby plants under the trees and in openings in the forest is one of the major resources of forest lands. The proper utilization of the forage resource by domestic livestock and game animals is therefore of primary importance in multiple-use management which seeks to obtain the maximum contribution to the national welfare, by a proper correlation of all the products, uses, and services of forest lands. The forage cover of forest lands plays an important role in the production of the Nation's domestic meat and wool supply and furnishes a livelihood to the stockmen whose herds or flocks graze it. It also supports a large and valuable wild-life resource and produces numerous miscellaneous by-products.

The use of the forage resource of forest lands primarily by domestic livestock, but to an important extent in some localities by game animals, vitally affects the management of such lands in several ways: (1) It is a source of direct current financial return; (2) it affects the reproduction of the timber crop; (3) it has a direct bearing on the value of the forest land for watershed protection, and (4) it has a direct influence on fire protection.

The forest land grazing problem logically divides into three important phases: The western-range phase, that which predominates in the South, and the pasture type in the farm woodlands. In the West the problem centers around the utilization of large areas principally of public land by many private owners of ranch property and livestock. In the South it largely concerns the use of extensive private forest areas often not owned by the stockman yet of decided value to the rural population. In the farming regions of the Central States, and in parts of the New England, Middle Atlantic, and Lake States, it involves small woodland areas on farms into which the

¹ Acknowledgment is due George Stewart, Hugh O. Cassidy, and Gordon D. Merrick for cooperation in the assembling of data for this section.

farmer turns his livestock. Thus the forest-range problem is one of broad social economy and land utilization. It affects directly or indirectly the permanent prosperity, development, and welfare of a considerable part of the Nation. The forest and forage conditions, as well as the character of use under each of the three major forest-grazing situations, are so distinct that each is considered separately.

WESTERN FOREST RANGES
EXTENT AND IMPORTANCE

The extensive forest ranges of the West, largely occupying the mountain areas, furnish a considerable percentage of the summer feed for the beef cattle, sheep, and range horses of the Rocky Mountain and Pacific Coast States. This region coincides with the three western forest regions of "Forest Land the Basic Resource" section of this report. It is composed of those States entirely west of the 100th meridian, and South Dakota. The region as a whole contains more than 214 million acres of land classed as forest, of which it is estimated that nearly 144 million acreas are grazed. (Table 1.)² These forest ranges include the relatively small parts usable for grazing of the dense forests such as the spruce-fir of mountain areas, the Douglas fir and redwood forests of the Pacific Coast, the lodgepole pine of the Rocky Mountains and Cascades, and the chaparral of California. They include the more open forest areas such as the ponderosa pine type, found from the Canadian to the Mexican borders and from the Great Plains to the Cascades and Sierra Nevada; and the woodland areas usually forming the lower fringe of the forest. Included also are the aspen forests largely in the Rocky Mountain States and the large areas of usable brush lands which are potential forests. In addition to these forest areas is a large acreage of open grassland and usable brush land so intermixed with the forest ranges that their utilization is an intergral part of the whole.

TABLE 1.—*Estimated areas of commercial and noncommercial forest lands grazed by livestock in the United States, by regions and classes of ownership*

COMMERCIAL AREAS											
[Thousand acres]											
Region	Total	Federally owned or managed					State	County and municipal	Private		
		Total	National forests	Indian reservations	Public domain	Other			Total	Farm woodland	Industrial
New England.....	3, 150	3	3	-----	-----	-----	-----	-----	3, 147	3, 147	-----
Middle Atlantic.....	3, 655	100	100	-----	-----	-----	-----	-----	3, 555	3, 555	-----
Lake.....	10, 852	15	-----	-----	15	-----	-----	-----	10, 837	10, 837	-----
Central.....	23, 635	500	500	-----	-----	-----	23	-----	23, 112	18, 560	4, 552
South.....	126, 870	2, 489	2, 433	56	-----	-----	258	-----	124, 123	19, 530	104, 593
Pacific coast.....	36, 411	18, 901	15, 450	2, 622	432	397	550	75	16, 885	4, 167	12, 718
North Rocky Mountain.....	18, 330	13, 627	12, 643	464	520	-----	374	-----	4, 329	2, 378	1, 951
South Rocky Mountain.....	23, 359	18, 937	14, 940	1, 817	2, 180	-----	361	-----	4, 061	28	4, 033
Total.....	246, 262	54, 572	46, 069	4, 959	3, 147	397	1, 566	75	190, 049	62, 202	127, 847
Eastern regions (except South).....	41, 292	618	603	-----	15	-----	23	-----	40, 651	36, 099	4, 552
Western regions.....	78, 100	51, 465	43, 033	4, 903	3, 132	397	1, 285	75	25, 275	6, 573	18, 702

² In this table, using as a basis the total commercial and noncommercial forest areas shown in "Forest Land the Basic Resource" section of this report, the estimated areas of forest land grazed by domestic livestock were calculated from Forest Service records and observations, the 1930 census, and "An economic survey of the range resources and grazing activities on Indian reservations", by Lee Muck, P. E. Melis, and G. M. Nyce, in hearings before a subcommittee of the Committee on Indian Affairs, U.S. Senate, 71st Cong., 2d sess. S.Res. 79, 308 (70th Cong.), and S.Res. 263 and 416 (71st Cong.), 1932.

TABLE 1.—Estimated areas of commercial and noncommercial forest lands grazed by livestock in the United States, by regions and classes of ownership—Contd.

NONCOMMERCIAL AREAS										
[Thousand acres]										
Region	Total	Federally owned or managed					State	County and municipal	Private	
		Total	National forests	Indian reservations	Public domain	Other			Total	Farm woodland
New England.....	1	1	1							
Middle Atlantic.....										
Lake.....	94	25			25				69	69
Central.....	315	84	84				22		209	209
South.....	22,138	296	296				165		21,677	14,337
Pacific coast.....	8,959	4,574	3,110	193	1,271		22		4,363	3,886
North Rocky Mountain.....	4,585	3,631	2,637	456	538		59		895	
South Rocky Mountain.....	52,006	38,283	14,974	6,520	16,689	100	2,644		11,079	4,827
Total.....	88,098	46,894	21,102	7,169	18,523	100	2,912		38,292	23,119
Eastern regions (except South).....	410	110	85		25		22		278	69
Western regions.....	65,550	46,488	20,721	7,169	18,498	100	2,725		16,337	8,713

ALL AREAS										
New England.....	3,151	4	4						3,147	3,147
Middle Atlantic.....	3,655	100	100						3,555	3,555
Lake.....	10,946	40			40				10,906	10,906
Central.....	23,950	584	584				45		23,321	18,560
South.....	149,008	2,785	2,729	56			423		145,800	33,867
Pacific coast.....	45,370	23,475	18,560	2,815	1,703	397	572	75	21,248	8,053
North Rocky Mountain.....	22,915	17,258	15,280	920	1,058		433		5,224	2,378
South Rocky Mountain.....	75,365	57,220	29,914	8,337	18,869	100	3,005		15,140	4,855
Total.....	334,360	101,466	67,171	12,128	21,670	497	4,478	75	228,341	85,321
Eastern regions (except South).....	41,702	728	688		40		45		40,929	36,168
Western regions.....	143,650	97,953	63,754	12,072	21,630	497	4,010	75	41,612	15,286

These forest ranges have represented on them nearly every character of ownership prevailing in the West—Federally owned and managed, State, and private. There are large Federal holdings. Of the 88 million acres of usable range lands within the national forests almost 64 million acres are classed as forest. More than 21.5 million acres of the unreserved public domain are forest ranges. The Federally managed Indian reservations contain some 12 million acres of forest land usable for grazing. The forest lands usable for grazing in other Federal reservations and withdrawals amount to about half a million acres. It is estimated that about 4 million acres of forest land in State ownership is grazed. Forest ranges under other public ownership or management are small and probably have little influence on the forest-range problem of the West. It is estimated that almost 42 million acres of privately owned forest land are grazed, including 15 million acres of farm woodland (1930 census). The increase in tax-delinquent land to the public may materially enlarge the forest-range area in certain classes of public ownership and make it important locally.

Among the larger private holdings are the areas still held by corporations from the grants made as subsidies for construction of

railroads and wagon roads and otherwise to encourage colonization and development. Many of these consist of alternate sections over extensive areas. The existence of land holdings in this form in a region where 640 acres is far from adequate as a range unit has complicated their management. Spanish and Mexican grants in the Southwest and California were usually made as solid bodies of land which, because of their relatively large size and continuity, are susceptible of management. Most of the large timber holdings are in the better commercial forest areas where forest growth is dense and grazing is a minor use. There are, however, in addition to these holdings a large number of small privately owned forest areas, most of which are grazed. In those areas where timber or woodland values are meager, many properties are held by their owners for the grazing value alone. Others serve as a base of operations for use of larger areas of adjacent public land.

Within or adjacent to almost every western forest range area are agricultural communities where prosperity is dependent upon the production of livestock. Many of the farms within these communities are small, far from markets and principally capable of producing hay or other feed crops. Without the aid of complementary forage furnished on the forest areas, a large proportion of these associated farm lands and the accompanying community life would never have reached the present stage of development. More than 4½ million acres of improved farm land and 22 million acres of private or leased grazing land, for example, are used in connection with the 83 million acres of national-forest land now grazed by domestic livestock.

The great bulk of the feed on the forest ranges is used by and the principal financial return comes from the cattle and sheep, although it also supports large numbers of horses and burros, mostly wild, some goats and hogs, and a few mules, to say nothing of game animals. It is estimated that during 5 to 8 months of the spring, summer, and fall these Western forest lands furnish feed for over 2½ million mature cattle, having a value in 1931 when prices were low of about \$85,000,000, and also nearly a million calves. Most of the cattle are of beef breeds; in only a few localities are dairy cattle run on forest ranges. It is estimated from the 1930 census that they represent nearly 40 percent of all the mature range cattle in the Western States. Some go direct to market as killers, but a large part of them go into feed lots for finishing.

Nearly 12 million grown sheep, largely ewes, which had in 1931 a value of about \$60,000,000, are estimated as grazing on forest ranges. The grazing period is from 3 to 5 months, chiefly in the summer, although in some places, grazing prevails in the spring, fall, or even winter. It is from these mountain-range areas that most of the lambs sold in the fall come. Since the average lamb crop is probably 70 percent, and these lambs graze in addition to the ewes, the large number of sheep grazed during a part of the year on forest ranges can be appreciated. Where the feed is abundant and succulent, many of the lambs go direct to market as killers. From the drier ranges, and especially those heavily used, most of the lambs are sold as feeders.

FORAGE PRODUCED

The ponderosa pine is the most extensive western forest type, reaching into nearly every State west of the one hundred and third

meridian, largely on mountainous slopes and plateaus at relatively low elevations in the northern part of its range and up to 8,000 feet or more in places in the southern part. The type furnishes good feed practically wherever it occurs. Ponderosa pine and its associated tree species usually grow in stands sufficiently open to allow the development of a great variety of herbs and shrubs. Over most of the type the feed produced is mainly bunch grasses. Grama grass—an excellent forage species, is abundant on the eastern slopes of the Rocky Mountains and in the Southwest. Many range weeds and shrubs add variety to the feed.

The sugar pine—ponderosa pine forests, which are principally in California, are more dense than the typical ponderosa pine areas, and therefore less feed occurs on the forest floor. The understory vegetation is mainly of browse, a large part of which is composed of such palatable species as bluebrush, birchleaf mountain-mahogany, and bitterbrush. Many of the other brush species are of low grazing value. Grasses and range weeds are important in places, but on forest slopes tend to dry up by midsummer.

Another forest type which furnishes considerable forage in the West is the aspen type. It occurs at medium to high elevations, usually on deep, rich soils which it helps to build up. It is of importance in Utah, Colorado, Wyoming, Montana, parts of Idaho, and northern New Mexico and Arizona. Beneath the aspen, which ordinarily grows in rather open stands, is usually a luxuriant understory of palatable grasses, weeds, and browse that is grazed with relish by all kinds of livestock. The aspen itself is prolific in producing sprouts that are rather palatable to livestock but that can be seriously damaged by too great foliage and twig removal through browsing.

The lodgepole pine forest, which covers large areas in the central and northern Rocky Mountains and on the east side of the Cascades, usually occurs in stands too dense to allow satisfactory grazing, especially since most of the herbaceous and shrubby species present are of low feed value. However, in the more accessible open stands, some use is made of the forage produced. In the western larch-western white pine forests of northwestern Montana, northern Idaho, and northeastern Washington, the stand is so dense that there is even less grazing than in the lodgepole pine.

The spruce-fir forest, which occurs at higher elevations in the mountains of the West, produces little forage in the more dense stands. However, in the subalpine phase of the type, where the stands are more open and patchy, good feed is produced in the openings sufficient in quantity to furnish some of the best summer range in the West.

In the Douglas fir and redwood forests of the west coast, a heavy undergrowth, chiefly of ferns and of salal and other brush species, occurs in spite of the dense stand of timber, and because of its low forage value renders these areas practically worthless for grazing. After destructive fires a luxuriant growth of moderately palatable herbaceous and browse plants ordinarily prevails for some years until forest reproduction shades it out. Good feed is also produced for a number of years on cut-over areas of these forest types that have been reseeded to forage plants.

The woodland type, consisting mainly of juniper in the North, of piñon-juniper in the central and southern Rocky Mountain States, and of digger pine and juniper in California, occurs at lower elevations than the commercial timber types. On the plateaus and rolling lands of the central and southern Rockies there is usually a fair ground cover of grass, often grama, beneath the open stand of trees. In spite of the naturally sparse forage cover, which in many instances has been seriously depleted by overgrazing, the woodland type is an important part of the western forage resource. In the California woodlands bitterbrush, bluebrush, and birchleaf mountain mahogany are often important. Repeated burns in this type of extreme fire hazard tend to replace the palatable browse plants with worthless brush and inferior annual grasses and weeds.

The mountain brushlands, at the lower elevations of the central Rockies and in the Southwest, consist principally of low-value oak brush. At the higher elevations of the Rockies cherry, plum, and willows are important. It appears that the oak brush areas were once good range lands with moderately palatable grasses occupying a large proportion of the vegetative stand, but the grass has been so depleted by overgrazing and the low-value brush species have spread to such an extent that at present it furnishes satisfactory forage only on a relatively small part of the type. In California and Oregon there are thousands of acres of mountain brushlands which have practically no grazing value because of the dense stands of snowbrush and manzanita which have largely become established following fires.

FOREST RANGE CONDITIONS

Few areas of forest range are still in a virgin condition. The fact that most commercial and many of the noncommercial forest areas were fairly well watered and had a cool climate, together with the good feed that was present, gradually attracted livestock owners to the forest lands. As a result of the keen competition for open range at the lower elevations, settlers in increasing numbers either located openings in the forest or pushed their flocks back into the extensive forest areas. With free range, an apparent abundance of feed, and a prospect for quick profits, money poured into the western livestock business in the eighties and excessive overstocking became general followed by depletion of forage. Accentuated by periodic droughts, the destruction of the forage plants, especially in the openings, almost reached denudation on many areas. Fertile top soils were washed away, slopes and valleys were cut by gullies, and farm lands, irrigation works, and other improvements suffered excessive damage from floods and erosion debris. Timber reproduction was devoured by the hungry animals. Fires set in an effort to open up brush areas, or with the belief they would improve range conditions, not only in many cases seriously injured soil and range values but destroyed valuable timber as well and made its reestablishment more difficult.

Creation of national forests, their protection from fire, and the regulation of grazing on them tended to stop deterioration and restore to some extent the forage on that part of the western forest ranges. For example, the high mountain forest ranges of Utah, according to stockmen, were practically dust beds in the late nineties. Study by the Intermountain Forest and Range Experiment Station on one area

in central Utah, after establishment of the national forest, showed that in a period of 15 years, the forage cover was, through careful management, restored sufficiently on the better soil areas to produce a grazing capacity four times greater in 1927 than in 1912. Similar improvement is recorded on many national forest areas in the West.

Some private owners, recognizing the folly of excessive use of their lands, have modified their grazing practices; but this has been almost impossible to accomplish where private holdings are so intermingled with public domain lands as to make complete use of the forage necessary to discourage intrusion of other livestock owners. Losses resulting from starvation in drought periods and forced shipments as a result of uneconomic conditions have relieved the public domain and most of the private lands for brief periods, but deterioration has continued on large areas of private and uncontrolled public forest lands, usually as a result of overstocking during periods with favorable markets, and as a result of recurrent drought.

Numerous examples might be cited of unsatisfactory range conditions still present on private and uncontrolled public forest lands and of their deleterious effects on the social, economic, and other conditions in the West. For example, on a private range in the ponderosa pine type of eastern Oregon the forage cover had been so closely grazed in 1920 that the area was practically a dust bed. Needles on the branches of timber reproduction within 3 feet of the ground had been eaten so completely that the branches were killed. Reproduction under 2 or 3 feet high was so closely grazed that it was making practically no growth, and the soil was so trampled that seedlings did not readily become established.

In Montana there is a large acreage of former grassland, occurring as scattered openings in the forest, on which the cover has been converted by overgrazing to low-value plants such as rabbit brush, yellow brush, and various weeds. W. G. McGinnies has found that this transition has reduced the grazing capacity of these areas from about 2 acres to about 11 acres per cow per month.

Studies by the Intermountain Forest and Range Experiment Station of spring-fall ranges in the foothills of Utah near the lower edge of the noncommercial forest type show losses of 40 to 90 percent in range values during the 50 to 60 years that they have been grazed. On areas protected from fire and grazing for a number of years, Pickford³ found that the valuable native wheat grasses and blue-grasses constitute 68 percent and the practically worthless sagebrush only 11 percent of the vegetative cover. Tracts which have been overgrazed furnish only three fifths as great a grazing capacity as the protected areas, and they have much less perennial grass, more than twice as much sagebrush, and a materially larger stand of low-value annual grasses than the protected areas.

A striking contrast, showing the value of good range management and maintained forage and livestock production, is afforded by the Santa Rita Experimental Range in Arizona and the depleted adjacent public domain. Although these ranges are mainly untimbered, the example illustrates what can be done with adequate control and good management on timbered lands. Areas on the outside range require from 3 to 4 times as many acres to support each animal as do similar

³ Pickford, G. D. The Influence of Continued Heavy Grazing and of Promiscuous Burning on Spring-Fall Ranges in Utah. *Ecology*, v. 13, no. 2: 159-171. 1932.

types on the experimental range. The number of cattle that have been grazed over the 17-year period have varied widely on the outside, losses have been far greater, calf crops have been much lower, the cost of producing calves has been greater, and their sale value less than on the experimental range.

Depletion of the under-story vegetation had reached such a serious stage and soil erosion had become so active on local areas of the woodland and brush types before creation of the Tonto National Forest that, even with regulation of grazing for the past 27 years, it has not been possible to arrest the deterioration. The seriousness of such depletion is evident when it is realized that the continuing erosion is greatly adding to the silt problem of the Roosevelt Reservoir, the principal storage basin of the Salt River reclamation project in Arizona.

The governor's special flood commission^{3a} concluded that the destructive floods of northern Utah in 1923 and 1930 (and which have continued in 1931 and 1932) were largely the result of the depletion of the vegetation on critical parts of the mountain watershed largely through overgrazing and fires and to some extent overcutting of timber. The evidence, from further intensive cooperative study of the cause of these floods by the Utah State Land Board and the Intermountain Forest and Range Experiment Station, points directly to denudation of relatively small areas on private lands near the headwaters of the affected streams. The damage in this heavily populated part of Utah has amounted to well over \$1,000,000 and several lives have been lost.

On the Kaibab National Forest and Game Preserve, depletion from overgrazing by game has become pronounced. The 1931 investigative committee made up of representatives of several national conservation, wild life, and livestock associations, and Federal and State agencies, concluded that the area is not now producing more than 10 percent of the nutritious forage that it once supported. Although the numbers of domestic livestock grazing on the area in 1913 have been reduced about 85 percent, the large increase that has occurred in the mule deer population is causing a continued deterioration of forage, especially on the winter range, which has meant starvation losses among the deer.

MANAGEMENT PROBLEMS

The conditions on western forest ranges as cited above show the definite need for development and application of management that will, through rehabilitation of the valuable subordinate forest vegetation and stabilization of range use, permit effective coordination of grazing with the watershed protection, timber production, recreation, and wild-life services of forest lands. Restoration of depleted forest ranges would ultimately not only benefit the livestock owners, but contribute to more satisfactory watershed protection, aid in protection of timber reproduction from grazing damage, and make available more abundant feed for wild life.

^{3a} "Torrential Floods in Northern Utah, 1930." Report of Special Flood Commission. Utah Agr. Expt. Sta. Circ. 92. 1931.

RELATION OF GRAZING TO OTHER FOREST RESOURCES

Soil is the basic forest-land resource. The retention of the fertile humus layer of top soil is essential to continued productivity. This depends on satisfactory maintenance of the protecting plant cover. In their original condition the forested slopes and valleys, except on a few areas of very unproductive soil, were well covered with dense forests or open tree stands and an under story of herbaceous and shrubby plants. This cover, together with its litter of decaying vegetable matter, had built up the surface soil into a friable condition, added to it a large quantity of rich organic matter, protected it from beating rains, and maintained it in a condition for maximum penetration of precipitation. The result was that the forest cover prevented excessive run-off or abnormal erosion. Through conservation of precipitation the productive soil yielded abundantly.

Overgrazing as well as fires set in an effort to improve forage have seriously depleted the herbaceous and shrubby vegetation and the litter on extensive areas of practically all forest types. Heavy rains falling on such exposed soils have started erosion which has stripped away much of the fertile surface layer. On an important portion of the Boise River watershed in Idaho, for example, depleted by past overgrazing, a survey by the Forest Service disclosed that only 35 percent of the grazed forest and brush types had escaped erosion. On the eroded portion a large part of the upper soil layer has been lost by widespread sheet and gully erosion. Six inches or more of the rich topsoil has also been lost from large areas of such important watersheds as the foothills of the upper San Joaquin Valley and the mountains of central Utah. The raw subsoil remaining is incapable of producing the plant cover the land once supported. Years of careful management will be required to restore the soil and vegetation, yet this must be done if the accelerated erosion is to be controlled.

It should be clearly understood that this loss of soil productivity by erosion following improper range practices affects not the stockman alone but the general public quite as deeply. Loss of productivity of the range resource, if allowed to proceed unchecked, removes taxable wealth and possibilities for current income, thus directly affecting community welfare. Furthermore, rapid run-off from depleted slopes, especially that from rainstorms, and the erosion debris which it carries increase the destructiveness of floods, and add greatly to the silting problem of reservoirs and of other irrigation works in the West. For example, an official of the Indian Service reported⁴ to Congress that the Zuni Reservoir in New Mexico had in 22 years filled with erosion debris to over 70 percent of its capacity, practically destroying its usefulness. The heavy investment in irrigated farm lands, in irrigation and power properties, and the urban values built up by these developments far outweigh the values represented in the livestock enterprise dependent upon the watersheds. Farm land values in the Boise irrigation project alone of over \$53,000,000 are equal to \$31 for every acre of the watershed. The public therefore, is vitally concerned in the condition of the watersheds.

⁴ Hearings before Subcommittee of House Committee on Appropriations on Interior Department Appropriation Bill for 1931, 71st Cong., 2d sess., pp. 304-305.

The importance of improving the vegetative cover is strikingly shown by Forsling⁵ in a study of two small subalpine watersheds in central Utah. On one the vegetation has been maintained since 1915 with a cover of about 40 percent of the soil surface. The other supported a cover of only 16 percent from 1915 to 1920. This cover was increased, partly by artificial reseeding, to 40 percent where it was maintained from 1924 to 1929. Over 95 percent of the annual surface run-off came from melting snow. Such run-off is the main supply for irrigation, supplemented by a delayed drainage of percolated snow water extending through the summer. Surface run-off from summer rainstorms on the watershed in depleted condition (1915 to 1920) swept away over 8 tons of sediment per acre, or for at least 3 years of record about 85 percent of that removed yearly. After improvement (1924 to 1929) the sediment removed annually by summer rainstorms was only about 1 ton per acre. For the periods 1915 to 1920 and 1924 to 1929 the difference between the two watersheds in surface run-off per inch of total rainfall was 0.042 and 0.011 inch, respectively, and in sediment removed per inch of rainfall, 21.8 and 2.8 cubic feet. Thus, as a result of improvement in the vegetative cover, a considerable reduction in the relatively small surface run-off from rainstorms was accompanied by a marked reduction in erosion.

On depleted areas of important watersheds, therefore, it is not sufficient simply to maintain a thin stand of vegetation. Management should be adjusted to facilitate as rapid recovery as is practicable. Although grazing can usually be adjusted through improved range management to meet watershed-protection requirements, there are areas within watersheds from which vegetation has been almost denuded or on which the natural balance is so insecure that any grazing in an effort to secure the negligible quantity of feed available would cause undue sliding of soil and prevent new vegetation from becoming established. Grazing should be excluded from such areas, at least until enough vegetation has been established to check the extreme erosion of soil from the slopes.

Large areas of western forest land are used for furnishing municipal water supply. The extent of such use is indicated by the fact that about two and one-half million people, living in over 700 cities or towns in the Western States, obtain their water supplies from areas within national forests. A pronounced public sentiment exists against the grazing of livestock, and especially sheep, on watersheds from which domestic supplies are derived. Sanitary engineers, however, hold that danger of contamination is not from the livestock but from the presence of human beings on the watersheds. Thus, the Washington State Board of Health, after an investigation of the watershed furnishing Walla Walla with its domestic supply, advised the city that removal of all stock would not insure purity and that filtration was the only practical way to bring this about. The United States Public Health Service in reporting on this case stated: "States have not passed laws to prohibit grazing on watersheds, because it is generally agreed among sanitarians that diseases are not transmitted by water from animals to man." Nevertheless in many instances, the Forest Service has entered into special agreements with municipalities for the more complete protection of their domestic supply of

⁵ Forsling, C. L. A Study of the Influence of Herbaceous Plant Cover on Surface Run-off and Soil Erosion in Relation to Grazing on the Wasatch Plateau in Utah. U.S. Dept. Agr. Tech. Bul. 220. 1931.

water from diminution or contamination, and grazing has been eliminated from about 720,000 acres of watershed lands on national forests for this purpose.

Ordinarily, serious damage to timber reproduction will not result from range management that is entirely satisfactory from the standpoint of the maintenance or restoration of the forage resource on western forest lands. Overstocking of the range as a whole, too great concentration of livestock on local areas, and grazing after forage has become coarse, dry, and of low palatability, or before new succulent growth has started in the spring, is apt to result in unwarranted damage to timber reproduction. The damage from grazing may become more of a problem where the sprouts and other growth of hardwood species are browsed readily, as for instance, commercially used aspen in Utah.

Where climatic conditions are rather unfavorable to establishment of timber reproduction, damage from grazing may be important. For example, the half million acres or more of timberland in the Southwest, on which satisfactory timber regeneration has been prevented or retarded by improper grazing, call for research to determine specifically how timber and grazing use may be best combined and adjusted to each other. Drought, and long periods between the combination of a good seed crop and favorable weather necessary for seedling establishment, are such serious obstacles to regeneration of the forest that grazing damage, which would otherwise be a small or even negligible amount, becomes important.

Studies by the Southwestern Forest and Range Experiment Station have shown that on cattle range in northern Arizona 27 percent of all the reproduction advanced beyond the seedling stage had in 5 years shown some damage from grazing and part of this had been browsed recurrently. During the first 2 or 3 years of the existence of seedlings, 6 percent were injured and 1.3 percent were killed. On sheep range 9 percent of the advanced reproduction was injured during the 5-year period. Of 2- and 3-year-old seedlings, 7 percent were injured and less than 2 percent killed. Injury to advanced reproduction largely takes the form of retarded growth. This together with the comparatively small seedling mortality from grazing may be the overbalancing factor preventing satisfactory regeneration of the forest, as in this instance, where at least 45 percent of the year-old seedlings and over 15 percent of the 2-year-old seedlings died from natural causes. These studies also indicated, irrespective of whether the range forage was depleted or overutilized, that lack of water or succulent forage is apt to increase the grazing of terminal shoots in dry periods. Evidently under these conditions livestock satisfy their thirst in part by browsing the succulent new pine shoots.

Studies by the Forest Service have shown that livestock should not be placed on summer forest ranges on areas in need of regeneration until the forage has made a good start and should not be left on the range after the more palatable plants are utilized. Sheep or goats should not be bedded or allowed to shade up in areas of timber reproduction, nor be driven through such areas in a close or compact band. Open herding and 1-night bedding grounds for sheep grazing and a close approximation to this in handling goats will help materially to keep damage to a minimum.

As shown in the section on "Wild Life A Forest Resource", the game and fish supported by forest lands and streams provide sport for hundreds of thousands of hunters and fishermen. Forests harbor a large proportion of the commercially valuable fur-bearing animals. They add materially to local business by expenditures of sportsmen and to State and county revenues from the sale of licenses. In addition to the wild life, the forest has educational and esthetic values which cannot be expressed wholly in terms of dollars and cents.

There is much forest land available for wild life which is too rough, supports too dense a stand of timber or brush, or is otherwise unsuitable for grazing by domestic livestock. On most forest lands grazed by livestock, however, there are or eventually will be problems of coordination and adjustments between wild life and domestic animals. The greatest difficulties so far have come in areas overstocked with domestic animals or with game or both, as on the Kaibab Plateau. Likewise an excess of elk south of Yellowstone Park during winter months has made heavy feeding of hay necessary to prevent losses. In general, there is ample summer range on western forests for present numbers of game animals, and in some cases for increases, without conflict with domestic livestock. Winter range on the other hand is insufficient on most areas even for present numbers.

Stockmen as a whole have as much interest in the maintenance of wild life as any other group of citizens. The interest of the public in a large and well-maintained wild-life supply may require curtailment or even elimination of domestic livestock grazing from limited areas of public-forest ranges. Thus, on national forests nearly 3 million acres of usable forest range have been closed to grazing by domestic animals for the benefit of game. Such feed reservations are in addition to the large areas of forest land unsuitable for livestock grazing which are usable by game animals.

Although a large part of the recreational values of forested lands are free to the millions of people who annually enjoy them, additional taxable wealth is created through the development of such facilities. Most of the western national parks are in forested areas, and thus large acreages have been set aside for the sole purpose of recreation and inspiration. From these parks grazing is practically eliminated. This is largely true on the forest areas included within State parks. On limited areas of national-forest land there is a heavy concentration of recreational use, especially such areas as those near Pike's Peak and Mount Hood, where literally hundreds of thousands of people visit the forest each year. Recreational needs for camp grounds, summer-home sites, and other cultural development may also lead to demands for local modification of range use. Such recreational use has brought about elimination of grazing from approximately 1,335,000 acres of usable forest ranges, usually in small units. Some owners of private-forest land have taken advantage of recreational opportunities and have made necessary adjustments in grazing.

Many unreasonable demands have been made by recreational enthusiasts for curtailment of grazing use on extensive areas of public-forest land where all things considered there is no conflict between such use and public interest. Horses and cattle, as well as shepherds with their flocks, on forest ranges are by many people considered an additional scenic attraction.

REVEGETATION

The restoration of depleted ranges to a well-vegetated condition is of the utmost importance. It is essential to more effective and stable livestock production, to more adequate protection of watersheds against abnormal run-off and erosion, and to assuring feed for wild life, as well as to enhancing other forest values.

Affording the native vegetation an opportunity to improve in stand is the most feasible means of restoring forage productivity on large areas of depleted forest ranges. On relatively small areas artificial reseedling would appear practicable. In order to assure range restoration of the important palatable species they must be allowed to develop sufficient growth to regain their vigor and to provide for reproduction either by maturing seed or by other methods of revegetation characteristic of some species. In extreme cases this must be brought about by total exclusion of grazing. However, except where grazing on a very badly depleted area would endanger watershed values it is seldom necessary to exclude livestock if grazing use is properly adjusted to the needs of the important palatable plants on the range. Such adjustments ordinarily will restore the plant cover as effectively as leaving the range ungrazed.

Of the several methods of revegetation developed by research in the Forest Service, deferred and rotation grazing has proved to be a very effective low-cost method applicable to many western range conditions. Simply stated, it consists of deferring grazing on a part of a range unit each year until the more important palatable forage plants have matured a vigorous growth and, where reproduction is by seeding, have matured seed. The rotation feature comes in through deferring grazing for a year or two on different parts of the unit in succeeding years. By such late fall use the mature seeds are shaken to the ground where they may be partly buried by trampling. During the following year light grazing or deferred use again may be desirable in order to promote establishment of seedling plants. On the average, ranges thus grazed for 10 to 15 years gain about 20 percent or more in forage value. Certain areas in central Utah have increased 50 percent, and some test areas 200 to 500 percent.

The more valuable forage species are so badly depleted on some areas that natural revegetation will take at best many years. On areas having favorable soil and moisture conditions and a thin stand of native vegetation, such as depleted mountain meadows and moist parks, and also on deeper alluvial soils rich in organic matter, sowing of seeds of the better cultivated forage plants and of desirable native range species, may greatly speed up restoration. In Ephraim Canyon on the Manti National Forest in Utah, for example, studies of the Intermountain Forest and Range Experiment Station have shown that the native wheatgrasses and brome, and the tame crested wheatgrass, Kentucky bluegrass, and smooth brome, among others, have tripled the grazing capacity of small test areas in openings within the forest. However, where the rich top layer has been lost the soil is unable to produce high yields, and although increases in forage production up to 25 or 35 percent were obtained, increases beyond that point will doubtless be slow until productive soil is again rebuilt. Several cultivated forage plants have given good results in extensive tests on favorable sites in the central and northern Rocky

Mountains and in the Pacific Cascade slopes. The forest range areas suitable to reseeding are individually small but total a considerable acreage as a whole. Reseeding ordinarily costs several dollars an acre. For range use alone it may not pay as compared to the slower natural revegetation. In the section of this report "A Watershed Protection Program", the need is pointed out for the early revegetation of about 900,000 acres in order to more adequately protect important watershed areas against undue run-off and erosion. As research develops cheaper and more effective methods, it is probable that artificial reseeding will take a more prominent place in plans for revegetation.

Selection and hybridization of range forages offer one of the greatest ultimate opportunities in revegetation if this work is undertaken in a comprehensive way to unite aggressive spreading habits of downy brome, for example, with the desirable forage habits of mountain brome. Such research is badly needed.

PRINCIPLES OF MANAGEMENT

In the administration of western forest ranges to bring about the proper coordination of grazing with other forest uses and the restoration and maintenance of the forest understory, there are four main underlying principles which should form the basis for plans and procedure. They are: (1) Use of the range by the class of livestock best suited to use it. (2) Adjusting the number of livestock to what the range can support satisfactorily on a permanent basis. (3) Adjusting the season of use to the most satisfactory period from the standpoint of correlating maintained feed production with greatest value from the use of the feed. (4) Distributing the grazing over the range in such a manner as to reduce damage around natural congregating places, to insure even utilization of all parts, to facilitate use of feed of particular value at certain seasons of the year, and to protect parts of the range needing special attention.

CLASS OF STOCK TO WHICH RANGE IS BEST SUITED

While the class of stock grazed on forest range will largely be governed by the present class grazing the range, by economic conditions, or by likes or prejudices of the particular owner, the trend should be toward the class or classes which can best utilize each particular range area. Cattle are attracted to open timber or woodland areas and grasslands or meadows in openings in the forest. They can be induced to utilize rather steep timber or brushy slopes, but the attempt to obtain a satisfactory degree of use of such areas is apt to result in overgrazing the more level and more open areas where cattle tend to congregate.

Sheep prefer a mixture of luscious grasses and weeds, and these are essential to the best development of lambs. They utilize open range to advantage and will penetrate and utilize areas of rather dense timber or brush. Usually they graze steep slopes more thoroughly than do cattle.

The advantage of adjusting class of stock to the range utilization possibilities is well illustrated by a national forest range in central Utah. This area was badly depleted before the creation of the forest but under use by cattle made slow improvement during the first 15

years of Forest Service administration. To correct the overgrazing prevalent in the local open valley areas and to speed up recovery would have required such heavy reductions in the number of cattle as to make further grazing by that class alone uneconomic. In 1922, owners of part of the cattle grazing on the range were permitted to replace them by sheep, and further changes were made later. As a result, the sheep have made better use of forage on the slopes and have been held off the open valley areas. The heavy grazing by cattle on the spring range and in the previously overgrazed valleys was practically eliminated. The spring ranges have improved from 100 to 200 percent and depleted parts of the summer range have improved as much as 400 to 500 percent. A more profitable basis of use of the range was developed and better watershed protection was afforded as a result of the improvement of the protecting vegetation on the depleted areas.

On areas in Texas, Arizona, and Utah, supporting a considerable quantity of browse there has been a tendency toward an increase in use by goats. If goats are grazed in reasonable numbers they can use many browse ranges to advantage where grazing capacity for cattle is so low that it is difficult for that class to be grazed satisfactorily.

NUMBERS OF STOCK WHICH THE RANGE CAN SUPPORT

One of the greatest and most widespread causes of range depletion has been overstocking. Too often stockmen have been tempted to obtain reasonably full use of an abundance of low-value species on their ranges, with the inevitable result that high-value forage was badly damaged or eliminated. An example of this is the efforts to obtain rather heavy use of oak brush on ranges of southwestern Utah grazed in summer by cattle. An experiment by the Forest Service on this type of range showed that under more conservative grazing, although fewer animals are grazed, these will yield a higher return than would a larger number of animals crowded onto the range.

The only safe basis of judging grazing capacity is the proper utilization of the more important palatable forage plants of each range area. In the West, as a whole, the main feed on forest ranges is furnished by bunch grasses, some succulent weeds, and a few browse plants that are of moderate to high palatability. Ordinarily average utilization of approximately 60 percent of the foliage production each year is as close use as these plants can withstand and maintain their vigor, although a few plants will withstand utilization up to 80 or 90 percent of their foliage. Use of all the foliage of the main forage plants robs them of their food-making parts and upsets their ability to compete with the lightly grazed vegetation. Such use leads to reduced grazing capacity and may result in rapid deterioration of range values.

There is a considerable difference in the quantity of forage produced in good years and in years unfavorable to plant growth. If stocking is based upon average forage production rather than upon the occasional very high forage yield, the intermittent years of poor plant growth can often be tided over without unwarranted injury to the range.

Precipitation is extremely important in forage production on forest ranges. Studies by the Forest Service of precipitation in relation to

growth of vegetation in different parts of the West indicate that below-normal conditions have prevailed on the average over much of the range during the last 8 to 15 years. Thus in the foothills of the San Joaquin Valley of California precipitation for the period from 1923 to 1931 was about 14 percent below normal; precipitation at Boise, Idaho from 1919 to 1931, inclusive, was below average in 9 years out of 13; while at Roosevelt, on the Salt River watershed in Arizona from 1922 to 1930, inclusive, 6 years were well below average and 3 years were only slightly above average. Such continued sub-normal precipitation, in a naturally semiarid region, makes it extremely difficult for the vegetation to maintain itself. If stocking is not adjusted currently to reduced forage production, rather serious depletion results. For example, on woodland ranges of southern Idaho, largely in private ownership and in the public domain, results from measured plots have shown that the forage cover has been reduced from 40 to 80 percent of the original cover over large areas.

On national forests, where an effort is made to adjust numbers of livestock to average feed production over the years and thus prevent overgrazing, the large increases in numbers of livestock during the war, as an emergency measure, resulted in overstocking on many national-forest ranges. It has been difficult, in view of the sub-normal precipitation, to reduce stocking rapidly enough to check range depletion. Where voluntary reductions were not sufficient it has been necessary to require reductions in the number of livestock. Fortunately, such required reductions have not been great or widespread.

PROPER SEASONAL USE

Grazing forage plants before they have made enough growth to withstand cropping has also been one of the principal causes of the deterioration of western forest ranges. If grazing promptly removes the first growth it deprives the plants of their food-making parts. As a result, the vitality of the forage plants is lowered, forage production is reduced, and the weakened plants are unable to produce fertile seed, or may be killed out entirely. Therefore, the date when grazing can satisfactorily begin should be based upon the development of the more important palatable plants on the particular range. With sufficient growth, utilization of part of it will not injure the vigor of the plants.

The close of a summer-grazing period should be governed usually by weather conditions and by the supply of feed. It is not advisable, as a rule, to graze the range in the fall up to the point that livestock can get only enough forage for sustenance.

PROPER DISTRIBUTION OF LIVESTOCK ON THE RANGE

Adequate distribution of watering places and salt offer the most practicable and economical means of procuring satisfactory distribution of cattle and full and uniform use of available feed.

Examples of beneficial results from more effective distribution of cattle on national-forest ranges are numerous. While in most instances the main result has been to overcome local overgrazing without reducing the number of cattle, one national forest supervisor, for example, reports an increase from 1,574 cattle to 2,200 on one range in 7 years as a result of some 66 new, well placed salt troughs. Another

reports an increase of from 800 to 1,300 cattle in 3 years by additional water development and the application of proper salting.

It is much simpler to obtain satisfactory distribution with sheep since they are continually under the care of a herder. The open-herding and bedding-out system of handling sheep, developed by the Forest Service from studying sheep grazing in pastures and through experimental tests of herding throughout the West, provides for quiet grazing in open formation during early morning and evening, a minimum of trailing and use of dogs, and bedding on a new ground every evening. Its advantages compared to the old bedding and herding systems are: (1) More even utilization of the forest understory, permitting more satisfactory maintenance of cover for watershed protection over the whole area grazed; (2) less heavy local damage to timber reproduction; (3) an increase in grazing capacity of 20 to 25 percent; (4) cleaner and larger wool clips are produced; (5) a greater average weight of lambs; and (6) great reduction in losses from poisonous plants. Thus there is a direct benefit to the stockman as well as to the range.

OTHER FEATURES OF FOREST RANGE MANAGEMENT

In the development and application of sound forest range management, properly coordinated with other forest uses, the following items need consideration: Range improvements and the control of poisonous plants, rodents, and predatory animals.

As better range management has been perfected, increasing attention has been given to the development of such range improvements as fences, water developments, driveways, pastures, corrals, and other equipment and developments for controlling grazing so as to obtain most satisfactory utilization of the forage. Often boundary fences are the only practical means of eliminating trespass and keeping stock within allotments, of dividing ranges for seasonal use, or segregating classes of livestock. Water is an absolute essential to effective use of the range. It is not abundant on many ranges of the West, particularly in the Southwest; therefore, it is necessary to drill or dig wells, construct reservoirs for catching run-off water, to improve springs, and to pipe water into troughs sufficient for watering all the livestock that should water at one time. Driveways and trails, bridges across swift mountain streams, riders' cabins, and other improvements also facilitate the handling of livestock and otherwise aid in range management that is needed for the fullest correlation of grazing with other forest uses.

In 1930 it was estimated that 5,414 cattle and 24,883 sheep were lost on the 1,300,000 acres of national-forest land known to be infested with poisonous plants. At conservative low price figures, this loss exceeded \$250,000. Over one half of the cattle losses are attributed to larkspur poisoning. Grubbing, at an average cost of about \$5 per acre, generally is an effective control measure for exterminating this weed. Grubbing a relatively small area may release a whole range from danger for several years. Chemicals have been used effectively to kill larkspur but cost more than grubbing.

Water hemlock and death camas may also be controlled by grubbing. It is thought, however, that the real remedy in many cases must be the indirect method of revegetating the range and maintaining a

liberal supply of the more valuable forage. Properly placed drift fences on infested cattle ranges and quiet herding on sheep ranges may serve as makeshifts until the more permanent remedies of eradication of the poisonous plants or range revegetation may be provided.

The presence of rodents on many of the forest ranges reduces seriously the subordinate vegetation needed for watershed protection and forage. The Forest Service estimates conservatively that on more than 15 million acres of rodent infested range in the national forests, including 5.8 million acres already treated, the grazing capacity is lowered fully 10 per cent by the destruction of forage plants and by the consumption of current growth.

The more serious aspect of rodent damage is the destruction of the protective vegetative cover of the soil, accompanied by a stirring up of the surface soil which exposes it to erosion. Unfortunately this sort of damage is most pronounced and serious on many areas where originally the soil was deep and highly productive.

The Bureau of Biological Survey, in cooperation with stockmen and the Forest Service, has done very effective work on many national forests, particularly in Colorado, Arizona, and New Mexico. The ranges cleared of rodent pests have shown improvement, but follow-up measures and continued extension of control work are necessary if permanent beneficial results are to be obtained.

Stockmen suffer serious losses every year from predatory animals, especially coyotes, wolves, and mountain lions. There are also heavy losses in game animals. The Bureau of Biological Survey is conducting a control campaign upon predatory animals, cooperating with State authorities, the Forest Service, and stockmen. While excellent results have been realized, it has been impossible with the funds available to cover fully the vast area of country infested.

It is the policy of the Department of Agriculture to control rather than to exterminate predatory animals. Many people believe that predators largely offset their damage to livestock where they contribute substantially to rodent control. Predatory animals are recognized as an important consideration in game management. Where surplus game animals cannot be utilized in beneficial ways control of predators may be lessened. Where the reverse is true control measures become a necessity to the maintenance of a proper balance between predators and game species.

THE SITUATION IN DIFFERENT OWNERSHIPS

The basic conception at the present time for use or disposition of forest ranges varies so widely between those public and private agencies owning such lands that distinctly different situations have developed. On the national forests the principle of multiple use of all resources for the benefit of local communities and the public prevails; but on the unreserved public domain, although Federal ownership implies an equal obligation in the public interest, there is an utter lack of policy either in use or regulation. Western States ordinarily aim to obtain as much revenue as possible from their forest ranges regardless of conservation of the resources. The chief concern of the private owner is to make a profit from his land. A review of each of these situations and the results of each is, therefore, warranted.

On publicly owned and managed forest ranges the method of disposing of the forage varies considerably. Range feed is sold either on

a per head or per acre basis, although the latter method is likely to encourage abuse of the range for immediate gain, unless the proper stipulations as to number of stock and seasons are incorporated in the lease. The grazing fee may be established either from competitive bidding or from an appraisal of the individual range unit which recognizes the priority of the established user. The fee based on appraisal, when fixed on a reasonable basis over a period of years, undoubtedly tends toward stability of range use, but experience has shown that it is subject to pressure for reduction.

The competitive-bid basis produces a larger cash return to the landowner and seems largely to eliminate the grounds for agitation for fee reduction, but requires very careful supervision to avoid the tendency to overgraze the range in an effort to pay out on the higher fee at the expense of future range productivity. It also tends to work against continuing use of a range unit by the same stockman and thereby lessens his interest in sustained range productivity.

NATIONAL FORESTS

The aim of the administrative policy of the Department of Agriculture in handling the 64 million acres of forest ranges within the western national forests is to obtain as fully beneficial use of the various resources of the land as is consistent with their permanent conservation. This concept, which lays stress on land management and on the use and perpetuation of the resources in place of reservation for the future, came in 1905 with the transfer of the then "forest reserves" from the Department of the Interior. Consistent with conservation and use of the timber, watershed, wild life, and other resources, the aim of the range policy on the national forests is (1) to build up the forage resource and its productivity through the development and introduction of the best possible methods of management, and (2) to promote a stable and prosperous use of these resources by permanent settlers on or adjacent to the national forests and dependent upon the use of forest ranges for satisfactory development of their own lands and livestock businesses.

No actual rights accrue to the stockmen using national forests, although they hold preferences for the use of range for certain numbers of livestock. These preferences have come to have considerable stability and, subject to the approval of the Forest Service, may be transferred upon the sale of ranches or livestock or both.

Grazing privileges within the national forests are not sold at competitive bid as is the common practice in disposal of timber. The range feed is disposed of on the basis of a reasonable fee determined after careful consideration of the forage available, accessibility, and other phases of use. In 1931 the average fee for cattle was 14.5 cents per head per month and the average fee for sheep was 4.5 cents per head per month. In 1932, because of the emergency conditions created by the 1931 drought followed by a severe winter, the fees were reduced by 50 percent by grant of the Secretary of Agriculture and the President.

Range management plans have been prepared for national-forest units. They are based upon the principles of forest-range management already outlined, and are administered so as to carry out the national-forest objectives.

The degree of success attained in the past 28 years in accomplishing the above objectives by means of the permit system on a per head basis is noteworthy. The improvement in condition of the range resource during this time, although it has not been uniform, is on the average marked. This in turn has furnished a corresponding improvement in watershed-protective values and in conditions favorable for wild life. Improved forage conditions also are of considerable value in sustained livestock production on national-forest ranges.

A discussion of grazing on national forests is presented in this report under "The National Forests."

INDIAN RESERVATIONS

The objective of Federal management of grazing on the 12 million acres grazed of the 14 million acres of commercial and noncommercial forested lands (including 6.7 million acres of piñon-juniper type) within the Indian reservations is to obtain the maximum benefit for the Indians. In carrying out this objective the Federal Government aims to obtain a maximum revenue for the Indians, insofar as it is possible, and perpetuate the range resource. A grazing plan has been or is being formulated for each Indian reservation. In connection with this, provision is first made for Indian-owned herds, range not needed by the Indians being leased under a system of competitive bids to the local stockmen. These leases run for periods of from 1 to 5 years. Leased lands are either (1) lands allotted to individual Indians, or (2) unallotted tribal lands.

The revenues obtained for lease privileges vary with the demand for and the condition of the range. They have been on the average 16.9 cents per head per month for cattle and 7.3 cents per head per month for sheep.

PUBLIC DOMAIN

The unreserved public domain contains approximately 21.5 million acres of grazed forest land. This area is the forested part of the land remnant held by the Federal Government after reservations, grants, and private appropriations have been made. It is a free range open to whatever grazing use individuals may make of it. The serious conditions on it reflect the absence of management. A rancher must graze the range near his property as heavily as possible, from early spring till late fall, or year long if in the region of mild winters, in order to avoid having someone else crowd in on him. During the summer growing season "tramp" herds may closely utilize feed that should, for the best interests of the industry as a whole, be reserved for winter. Such herds often come in and profit by whatever protection local stockmen have given the range.

It is of the utmost importance, if such range is to be saved from utter destruction, that these forested public-domain areas, as well as the many million acres of nontimbered range land in the public domain, be given a status which will make possible management and restoration.

STATE LANDS

The aim of western States, in handling the State forest land grazed by livestock, of which 4 million acres now remain, has usually been to convert the land into cash by sale or to obtain the greatest pos-

sible cash income from leasing. Much land formerly held by States has been sold to any who would purchase, frequently to the highest bidder at public auction. Two bad results have arisen from this plan. In some cases the land has brought so little that it was virtually a gift to the purchaser. In other cases because of the anxiety of several stockmen, some of them transient, the price bid was so high that it was never paid and the land after being badly abused reverted to the State.

Leasing for the largest obtainable cash return has meant in most cases competitive bidding, whereby the previous lessee had no assurance that he would have continued use of the land. In some States there is provision for protecting the interests of the previous resident lessee, although he may have to increase his rental to meet a higher bid. Under great necessity to obtain a certain area, a stockman might be forced to meet an unreasonable bid, perhaps by an alien who bid very high in order to get a local foothold, often with the idea of extending his grazing to other lands. There are seldom any provisions as to how the range shall be grazed or any field supervision and ordinarily the stockmen use it as they deem best. Lack of provision for adequate management in disposal or lease makes for lack of assurance of permanency, and in some cases State lands have deteriorated until they correspond closely in condition with the unreserved public domain.

PRIVATE FOREST RANGE LANDS

Nearly 42 million acres of privately owned forest land in the West is grazed by livestock. More than 15 million acres of this area is in farm woodlands, according to the 1930 census. The remainder is in larger holdings mainly owned by stockmen, lumber companies, or other corporations. Holdings of stockmen are chiefly in noncommercial forest types. While the majority of private owners use their forest ranges with the expectation of continuing grazing use, they fail to appreciate what is happening to the range under the heavy use commonly practiced. Little concern is given to the timber and other resources. The major objective is maximum income. These ranges, as a whole, have declined in grazing capacity to a condition almost as bad as that on the public domain. There are of course individual privately owned ranges that are well managed and on which forage, timber, and watershed-protective conditions have been well maintained. Occasionally forest range lands owned by railroads and other corporations are leased under definite stipulations as to the manner and degree of use, but this is the exception. In the numerous cases where such stipulations are not made the result is nearly always serious depletion of the range.

A considerable part of the private land within the national forests is turned over to the Forest Service to be managed under the same plans that apply to adjacent Government land. Such land is ordinarily kept in reasonably good condition.

FOREST RANGES IN THE SOUTH

The forests of the South furnish considerable feed for livestock, particularly for cattle during the spring and early summer. The region here considered is identical with that presented in "Forest Land the Basic Resource" section, and extends from Texas, Oklahoma, and

Arkansas, through the Gulf and Atlantic coastal States to Virginia and including that part of the southern Appalachians within these States. It is estimated that nearly 150 million acres (table 1) of the 217 million acres classed as forest land is grazed at least to some degree. The commercial pine and hardwood forests have been largely cut over and although they are now mainly in some degree of restocking to forest growth, most of the area supports a good growth of grasses and shrubs suitable for livestock grazing. A large part of the noncommercial forest lands are grazed.

Nearly 15 million cattle, 9 million sheep, and over 9½ million hogs (1930 census) in the region as a whole, are on farms, forest, improved pasture, and untimbered range lands. Texas and Oklahoma together have 8.7 million cattle, 7.2 million sheep, and 2.6 million hogs, a part of which graze on forest lands in the eastern sections of these States. A still larger proportion of the cattle, sheep, and hogs in the rest of the South obtain feed from the forest range. The grazing of livestock on native forage produced on forest lands furnishes a livelihood or supplemental income to a substantial proportion of the rural population and in some instances provides a current return to the landowner to meet carrying charges. Timber growing and adequately controlled livestock grazing seem to represent a dual use which can contribute substantially to economic use of forest lands.

The "Forest Land the Basic Resource" section of this report shows that approximately 98 percent of the forested area in the South is privately owned. Nearly 70 million acres is in farm woodlands, of which, according to the 1930 census, nearly 34 million acres, or almost half, is pastured. It is estimated that about 112 million acres are grazed of the 143 million acres in other types of private ownership, chiefly large holdings of lumbermen and turpentine producers. Of the area in public ownership, amounting to less than 4½ million acres, the largest part of which is in national forests in the southern Appalachians, it is estimated that over 3.2 million acres are grazed. A tax-delinquent situation has developed to such an extent during the past decade that the forest lands reverting to the public for nonpayment of taxes are reaching sizeable proportions.

The forest lands in the South are largely unfenced and are for the most part grazed by livestock of local residents, who seldom own very much of the land they use for grazing their livestock. Furthermore, the leasing of grazing rights on privately owned timberlands is not common practice. In most States these unfenced forest lands are generally considered public ranges, and in the southern pine type commonly are burned annually or periodically by the local livestock owners. The original timber has been largely cut off, so that the peak of forest productivity has passed for the time at least. The practice of annually burning over the grass and other ground cover during the dormant period interferes with satisfactory forest restocking on much commercial forest area.

Much progress has been made in improving livestock-raising conditions and methods in the South through cooperative efforts of the United States Department of Agriculture and the various State agencies. Perhaps the most outstanding accomplishment has been the elimination of the Texas fever tick of cattle from most of the area. As a result, pure-bred cattle have been brought in extensively to improve the type and grade of native stock. The development of

improved pastures and supplemental feeds with introduced cultivated forage plants has greatly improved feed conditions on farms. All of these have aided in a more systematic and profitable livestock-raising program. And yet a poor grade of livestock and a care-free type of management still prevails on much of the forest range in the South. The wide extent of forest lands and the large amount of herbage produced offer great possibilities for livestock grazing in conjunction with the growing of timber crops.

FEED PRODUCED ON FOREST LANDS

The principal forest-range types in point of area are the longleaf-slash pine, extending along the lower Atlantic and Gulf coasts, and the shortleaf-loblolly pine-hardwoods type, which forms a wide belt through the heart of the region from east to west. The less extensive oak-pine and oak-chestnut yellow poplar types along the northern edge of the region are grazed but little. Grazing is also light in the river bottom hardwoods cypress type along the Mississippi and other rivers. But the oak-hickory forests, west of the shortleaf loblolly pine-hardwoods type in Texas and Oklahoma, are extensively grazed.

The longleaf-slash pine type is one of the most important stock-grazing areas of the South. Observations by State and Federal agricultural workers indicate that the so-called "wire grasses", including certain andropogons, needlegrasses, muhlenbergias, and dropseeds and broomsedge are among the most important native grasses. Introduced grasses, such as Bermuda grass, carpet grass, Dallis grass, and crabgrass, are well established on limited areas, usually in clearings. They are eaten readily by livestock and often are of great importance as forage. Lespedezas, tick-trefoils, ground nuts, clovers, and other legumes are also common in this region.

The shortleaf and loblolly pine-hardwoods type is rich in botanical species, the most important from a grazing standpoint including broomsedges and needlegrasses among the grasses, deervetch and tick-trefoils among the legumes, and cottonwood, sassafras, black willow, oaks, and in the eastern portion, yellow poplar, among the species browsed. Tree growth is often so dense in the more southern of the Mississippi River Valley bottomlands as to limit grazing. The canebrakes, however, furnish excellent cattle grazing unless overgrazed or impaired by fire.

The chief timber types in the southern Appalachians are the oak-chestnut-yellow poplar, and, at lower elevations, the oak-pine type. Forest Service and other studies indicate that besides the reproduction and accessible portions of such hardwoods as oak, hickory, chestnut, yellow poplar, and maples, numerous shrubs are browsed. Here also occur a great variety of native woodland grasses, many of which are valuable for domestic livestock. This is the region of greatest development and abundance in this country for rhododendrons, azaleas, and kalmia (mountain-laurel), all of which are highly poisonous to livestock but usually ungrazed. The grassy "balds" or treeless areas of the southern Appalachian Mountains furnish natural feeding places of high grazing capacity for cattle and sheep. The cover of such balds is largely redbud, Kentucky and woods bluegrasses, with a number of palatable sedges.

The noncommercial forests, principally in Texas and Oklahoma, are not only extensive in area but also are used considerably by livestock. The oak-hickory belt in Texas, west of the shortleaf and loblolly pine-hardwood type, usually contains post oak, blackjack oak, and hickory. The accessible tender shoots and sprouts of the tree species (especially on cut-over areas), as well as those of sassafras, persimmon, and other smaller trees are browsed. Among the grasses the needlegrasses, panic grasses, and broomsedge furnish considerable forage.

FOREST RANGE PROBLEMS

Among the more important problems in the grazing of southern forest lands are: The widespread practice of uncontrolled burning to remove unused grass, the serious damage by hogs in rooting out longleaf pine seedlings, and the grazing of sprouts of valuable timber species in the southern Appalachian hardwoods. Another very important problem is the need for a more adequate coordination between the grazing on forest ranges, the use of improved pastures, and supplemental winter feeding.

In a later section, "Protection Against Fire", it is shown that an average of 37,571,500 acres of forest land were burned annually from 1926 to 1930 in the South, mostly on areas where no organized attempt was made to control fires. A large part of these fires occur in the southern pine belt and are mainly set by livestock owners to remove the rough and to keep down the undergrowth. Fires are also set in the belief that they contribute to the control of insect pests, and in some instances to keep the country open for hunting. Many stockmen also burn the forest undergrowth in the belief that the quality of forage is improved. Green,⁶ reports substantially greater gains in weights of cattle on burned forest range in southern Mississippi as compared to cattle on an adjacent unburned area.

Forest Service studies show that uncontrolled fires have already caused great damage to southern pine forests, and are especially damaging to turpentine trees, which are seldom carefully protected after the turpentine operations have ended. Uncontrolled fires on forest land kill out pine reproduction and retard the restocking of many tree species, although longleaf pine is particularly resistant to fires. The coordination of grazing use with timber production requires either the prevention or the control of fire to insure the success of forestry undertakings.

In the southern Appalachians burning to improve forest range is much less widespread than in the pine belt of the South. Unfenced forest grazing is of less importance than formerly because, with the better grade of livestock now being raised and fence laws which make the stock owner liable for trespass, more of the animals are being grazed on improved farm pastures. Some sporadic grazing damage to the better tree species such as yellow poplar, oak, and chestnut occurs in the coves and on lower mountain slopes when cattle congregate there.

Studies by the Forest Service have shown that considerable damage is done to longleaf pine reproduction by hogs, which run at large throughout the year. Mast—acorns and nuts from hardwoods

⁶ Greene, S. W. The Stockman's Interest in Protecting Forest and Range from Fire. Proc. Eleventh Southern Forestry Congress. 1929.

along stream bottoms—furnishes a valuable feed for hogs when available. Hogs relish the seedlings and the spongy root bark of longleaf pines, especially in early spring, when the mast becomes scarce, or when they are driven out of the bottoms by high water. They often destroy whole crops of seedlings by rooting them up in their search for food. Longleaf seedlings several years old and sometimes up to 6 feet in height may be killed. Considerable damage may be done even to larger trees by removal of the outer layers of bark from the lateral roots. The ranging of hogs under adequate control can make good use of the forest range during a comparatively long season without serious damage, but wild hogs in large numbers ranging continuously over the forest do not fit into a forward-looking plan for proper management of the longleaf pine forests.

The progress in development of improved pastures and forage crops already effected on farm lands by the Department of Agriculture in cooperation with State agricultural experiment stations and extension services is considerable, as shown by the number of publications available on these subjects. The coordination of forest-range grazing with these improved pastures and with supplemental feeding presents an important problem in the South.

In the Pine Belt, for example, the main forest range forage plants make their best growth and are eaten most readily during the spring and early summer. The graphs accompanying Greene's article in the Proceedings of the Eleventh Southern Forestry Congress indicate that steers usually make rapid gains in weight on forest pasture in southern Mississippi from early April through June and part of July, but gain very slowly or even lose weight during the remainder of the year. A number of forage plants used in improved pastures, such as carpet grass, Bermuda grass, and lespedeza furnish good grazing until in October. While it is true that these pastures can be utilized from any time after March or April, the good gains indicated by Greene as possible on forest ranges through July might make it advisable to remove livestock from the forests in late summer and place them on supplemental pastures saved for that purpose. Some stockmen are finding it advantageous to have fields of Abruzzi rye, Italian ryegrass, or winter oats and legumes such as burr and crimson clovers and vetch to use for winter grazing. Where small cultivated areas within the forest can be used for production of these pasture plants and opened for grazing during the period it is desired to use them, livestock might be grazed year-long within the forest.

The 2,700,000 acres of timbered land grazed within the national forests of the South constitute areas, even though comparatively small, where regulated management of the forest-range resource can be developed and demonstrated for those types of which they are representative.

However, with 98 percent of the forest land in the South held in private ownership and with much of the area used for grazing by other than the owners of the land the problem of obtaining the application of more desirable practices is largely one of education. Much intensive study will be needed to develop the most desirable management and effective coordination of timber growing, grazing, and other uses of forest lands.

FOREST GRAZING IN THE CENTRAL, LAKE, MIDDLE ATLANTIC, AND NEW ENGLAND STATES

On the forest lands of the Central, Lake, Middle Atlantic, and New England States grazing is confined almost entirely to farm woodlands. It is mainly a pasture type, as contrasted to the open range type of grazing prevalent in the West and South. The most intensive use of forest lands by livestock occurs in the Central States, but farm woodlands are pastured at least to some extent throughout the whole region.

The area under consideration is so large and the use of the forest lands by livestock offers such diverse conditions in different sections, that few generalized statements are possible. Of the 63 million acres of farm woodland in these regions over 36 million acres (1930 census), or 57 percent, are grazed. There are approximately 106 million acres of forest land in other private ownership, mostly in larger holdings of sufficient size for commercial lumbering operations. These have been mainly cut over. It is estimated that excluding farm woodland there are less than 6 million acres of forest area grazed to any great extent by livestock in these regions.

The grazed forest areas have an important part in the social welfare of the regions. Although they support only a diminishing residue of the original forest cover, they still produce a portion of the wood used in these regions and can be restored to a higher state of timber productivity with careful management. Only in the more open timber stands is sufficient forage produced to furnish a supplemental income of much value to the owners but, on farm woodlands especially, the trees are often used to advantage as shelter for livestock. On highly erosive soils, as shown in the section on "Watershed and Related Forest Influences", these forests have a high watershed-protective value, where the undergrowth and forest reproduction have not been too severely damaged by excessive grazing and trampling. Forests are especially desirable in these States for recreational, educational, and wild life uses. Recreational and wild life values are practically impossible to determine fully in terms of money, but generally are recognized as necessary for the complete well being of both the urban and rural population.

The function of forest pastures in the livestock industry varies considerably in character and value in different parts of this group of forest regions. According to the 1930 census, these regions have a total of over 36½ million cattle, both beef and dairy breeds; 17½ million sheep; and 41½ million hogs. Of these livestock, approximately 59 percent of the cattle, 69 percent of the sheep, and 82 percent of the hogs are in the Central States. A considerable portion of the livestock use forests at some time during the year. In the Corn Belt States—Ohio, Indiana, Illinois, and Iowa—the farm woodlands are so heavily stocked that little forage remains even in the open stands, and their principal value is for shade and protection to livestock. Outside of the Corn Belt, the farms have more open pasture land available and fewer stock; consequently the intensity of grazing in the forests is considerably lessened.

THE FORAGE ON FOREST LANDS

Studies by the Department of Agriculture and State experiment stations have shown that in the Lake, Middle Atlantic, New England, and most of the Central States little real forage is produced in the

understory of a good forest. Reproduction and accessible tender shoots of hardwood trees and shrubs may be browsed by livestock, but such use is discouraged or prevented where timber production is the objective. Mast from oaks, hickories, walnuts, beech, chestnut, and pines, where these species occur, is used widely by hogs. As the forests are opened up by clearing or grazing, numerous grasses appear, many of them naturalized introduced species. Studies by the Bureau of Plant Industry show that many of these incoming grasses are very worth while from a grazing standpoint. Where the soil is fertile, the highly valuable Kentucky bluegrass and white clover furnish excellent pasturage; and if the habitat is moist, bent and red top grasses and frequently white clover supply good feed. After continued heavy grazing, these better grasses give way to less valuable grasses and weeds.

The oak-hickory type which forms a wide belt through the middle of the Central States and extends along the southern and eastern portions of the Lake States forested area is extensively grazed. The oak-chestnut-yellow poplar forest, furnishing some browse and mast, occupies a broad belt along the length of the Appalachian Range. The birch-beech-maple-hemlock type extends in a belt mainly through the Lake States well into the northern Middle Atlantic and New England States. On the richer soils of which it is characteristic, naturalized grasses and white clover are locally present and supplement the native herbage.

The spruce-fir-hardwoods type, over most of its range, is usually too dense for grazing except by game. In the Lake States, if the forest is sufficiently open, a number of important grasses occur but the type is now little used by livestock.

The oak-pine type of southern Missouri and on many south-facing hill slopes from southern Ohio to the Southern States supports native grasses and sedges which together with shrubby growth and mast furnish feed for livestock.

FOREST GRAZING PROBLEMS

In the New England, Middle Atlantic, and Lake States forest grazing is almost entirely on farm woodlands. In the Central States it is estimated that approximately 77 percent of forest area used by livestock is farm woodland. In the Lake States, some attempts have been made to graze the forage produced in the understory of the forest, and the herbaceous cover on cut-over hardwoods, spruce-fir, and the pine forests, but little success has been obtained. Forest grazing problems at present, therefore, are confined almost exclusively to farm woodlands.

The need for coordination between grazing and timber production on farm woodlands is becoming increasingly important on many areas, especially in the Central States. Damage to timber reproduction is especially serious in the Corn Belt, in spite of the fact that the real feed for the livestock grazing in woodlands is produced on the farms from cultivated forage crop plants and on improved pastures. Estimates by the Central States Forest Experiment Station show that the woodland pastures of the Corn Belt are being used by at least 5 times as many livestock as the grazing capacity of the herbaceous and shrubby vegetation would support. The principal

effect of this overgrazing on the farm woodlands is the retardation, deformation, and usually the complete elimination of timber reproduction between the heights of 6 inches and 12 feet. This, combined with the death and occasional cutting of mature timber, is rapidly converting the woodlands of the better agricultural sections into open pastures.

Overgrazing of farm woodlands in the Central and Northeastern States is ordinarily detrimental to watershed values of the forest. For instance, studies by the Central States Forest Experiment Station in the farm woodlands revealed the marked effect of grazing upon the depth of litter and humus. On 87 plots in the oak-hickory type, ungrazed plots had an average depth of litter of 1.8 inches; lightly grazed, 1 inch; moderately grazed, 0.7 inch; and heavily grazed, 0.4 inch.

The average depth of humus on the plots under the grazed conditions in the order named above was 0.5, 0.3, 0.2, and 0.1 inch. The top 9 inches of soil was found to be 15 percent heavier and more compact in grazed than in ungrazed woodlands. As shown in the "Watershed and Related Forest Influences" section of this report, litter, humus, and soil porosity are important for conserving precipitation and preventing undue run-off and erosion.

If timber production appears to be the best source of income, grazing should be adjusted to protect forest reproduction and assure future timber crops. To continue to use entire woodlands on many farms so heavily that timber reproduction is seriously damaged would hardly appear best from either the standpoint of timber production or most effective farm-land use. At least 1 million acres now classed as commercial forest, mainly in the Corn Belt, should be considered as primarily valuable as shade and shelter for livestock, and so withdrawn from the area of commercial forest. This acreage would be made up of a great many small units, doubtless of a few acres at most, on individual farms where a part of the present grazed woodland would be fenced off for livestock. From a forestry standpoint it would be best if grazing were eliminated from the balance of the woodland. Where grazing is continued in farm woodlands held for timber production, it should be limited to the actual feed available, so that undue damage will not be done to the timber reproduction and forest litter. The fundamental consideration in the use of forest pastures in these regions is primarily one of economic values. The whole situation demands further study of coordination of grazing with timber growing and other forest-land uses and an adequate program of extension and education to apply the practices developed.

MINOR BY PRODUCTS OF THE FOREST

By W. A. DAYTON, in charge of Range Forage Investigations

In order to form an adequate concept of the complexity of the forest community and to understand its full actual and potential importance, it is necessary to realize the enormous number and variety of organisms of which it is composed. In addition to upward of 1,200 species and varieties of trees indigenous to the approximately 600 million acres of forest land in this country, and to the myriad sorts and sizes of forest zoological denizens, there are probably at least 25,000 species of flowering plants and ferns, besides a vast uncounted host of lesser vegetation, including mosses, algae, lichens, fungi, and bacteria.

As Clapp has pointed out in *A National Program of Forest Research* (published by the American Tree Association, 1926), the forest, while exceedingly complex, is a biological unit wherein all the component parts affect the whole, often vitally. It is not possible in this brief account to do more than hint at a few of the beneficial and detrimental effects of the subordinate forest vegetation on the forest itself. This complex forest society of living organisms produces numerous miscellaneous byproducts which, although of relatively minor importance in themselves, are yet in the aggregate of great actual and potential value to industry and society. Among those already established on a commercial basis are maple sugar and sirup, tanbark, sumac, cascara bark, wild nuts, blueberries and other wild fruits, and ornamental plants.

The maple sugar and sirup industry is chiefly confined to the optimum range of the sugar maple tree, which (aside from adjacent portions of Canada) embraces eastern New England, New York, Pennsylvania, the Lake States, the southern Appalachians, and a few other localities of the northern and northeastern States. Along the Pacific coast the bigleaf maple, and in various other places the silver maple, boxelders, and a few other species of maple are occasionally tapped. The sugar maple, with its varieties, is usually dominant and ordinarily comprises from 25 to 75 percent of the total stand of approximately 62,500,000 acres of the northern maple-beech-birch type in the United States in which the tree characteristically occurs.

The heaviest sap production, aside from the effect upon it of certain climatic factors, appears to be associated with great leaf production (large crown and numerous branches), together with good soil moisture and humus conditions, and a moderate amount of sunlight; in general, the maple sugar and sirup industry requires a different type of tree from the taller, clean-boled, few-branched, narrower-crowned type favored by the lumber trade. The maple sugar and sirup industry, with a product valued at several million dollars annually, is largely conducted on privately owned lands by individual farmers or associations of farmers. Because of present economic conditions current price quotations for "sugar-bush" lands hardly represent fair valuations. The George Washington (formerly Shenandoah) National Forest, Va., is issuing sugar maple tapping permits at 10 cents per tree per year. The latest census figures show for the 9 leading States, 34,823 farmers reporting, 1,341,491 pounds of maple sugar and 2,341,023 gallons of sirup produced during

1929, which was a relatively poor season. The industry is a leading one in parts of Vermont, New York, Ohio, and other States. It furnishes employment and a source of income in late winter or early spring, and has an important bearing on local phases of transportation, such as roadbuilding, as well as on the confectionery industry generally.

The American tanning trade utilizes an enormous amount of forest products, both domestic and imported. In 1925 (the latest year for which census figures are available) 158,942 tons of hemlock bark, 103,775 tons of oak bark, 104,268 tons of chestnut wood, and 1,139 tons of sumac extract from American forest lands were consumed in the tanning industry. This material is chiefly produced in the Eastern, Southeastern, and Pacific Coast States, although oak and sumac species are distributed (and potentially available) almost throughout the United States.

Native chestnut is the source of nearly one third of the vegetable tanning materials grown in this country, wood unsuitable for lumber purposes being chiefly employed for this purpose. The natural range of chestnut in the United States is from central New England, through Pennsylvania, Maryland, and northern Virginia, following the southern Appalachians (where it reaches its best development) into the northern parts of Georgia, Alabama, and Mississippi, and westward into central and eastern Tennessee and Kentucky, to Indiana and the more eastern portions of lower Michigan. Unfortunately the chestnut blight has already spread throughout the range of chestnut. In 1930 the Division of Forest Pathology of the Bureau of Plant Industry estimated that at least 80 percent of the chestnut trees as far south as Virginia were either dead or infected with blight, and the infection is still spreading. Thoroughly healthy stands are rare, perhaps nonexistent. Fortunately, however, the wood loses its tannin content very slowly, and trees dead 25 or 30 years are, so far as their wood is then sound, practically as good as living trees for use in the tanning industry. In spite of this devastating scourge, commercial stands of chestnut still occur, occupying perhaps about 15 million acres, composed of living (though mostly diseased), dying, and dead trees. Blight-killed trees remain usable for lumber for 5 or 6 years after death, and for an even longer period for other purposes, such as posts, pulpwood, fiber board, and tannic acid.

Large sums of money have been spent by the Federal Government, by the State of Pennsylvania, and by private individuals in Delaware, and energetic effort has been made by other public and private agencies to combat the chestnut-blight disease, without avail. Many authorities believe that the species, unless some unforeseen method of treatment or control soon appears or blight-resistant strains are shortly developed, is doomed to extinction, necessitating reliance on oak, pine, and other species eventually to supplant chestnut. Ashe (in 1912) estimated the yield of average 60-year-old stands of chestnut in Tennessee, based on a cut of trees of 10 inches in diameter and larger, as varying (according to site quality) from \$32.70 to \$66.80 per acre annually, with stumpage based at \$1 a cord. Under such conditions and in the event that means were later forthcoming of stopping the blight or of developing immunity, chestnut growing on these cheap forest lands might be a very profitable undertaking.

Hemlock bark is the most important single item in American-produced tanning material and is especially profitable in connection with pulpwood and fiber-board production, for which latter purposes peeled logs are preferred. Since under present conditions the price of hemlock is decidedly low, the value of the species for tanning, in addition to its use for paper pulp and fiber board is of distinct advantage in lumbering operations. The eastern hemlock is confined (aside from southeastern Canada) to New England, the Middle Atlantic States, the Appalachian Mountains, Ohio, Michigan, and Wisconsin. Latest available estimates of its stand in the United States are about 12 billion board feet, the greater part of which is privately owned. The western hemlock, which occurs largely on Federal lands, ranges from Alaska to western Montana and northern California, the latest available estimates of its stand in the United States, exclusive of Alaska, being about 85 billion board feet. Its bark is somewhat richer in tannic acid per unit area than that of eastern hemlock but is only about half as thick, so that it is inferior to its eastern relative as a source of tanbark.

The bark of cascara buckthorn, a tree occurring from British Columbia and the southeastern borders of Alaska to western Montana and northern California, is an important item in *materia medica*. The tree is largely limited to areas along or near streams and to swales and moist slopes, and usually occurs in admixture with other species; probably more than half of the stand is privately owned. In general the bark is best handled as a forest byproduct, but the specific use of certain specially favorable lands for growing cascara, under private ownership, is a possibility worthy of future consideration. Nearly all of the commercial stand of cascara buckthorn is west of the Cascades, where it has been estimated that 75 percent of the region, or about 15 million acres, will produce bark in paying quantities. Full utilization of this resource would be ahead of present consumption but hardly in excess of possible future demand. In removing the bark care must be taken not to girdle the tree, injure the roots, remove more than about a quarter (or at most a third) of the bark, or to have the incised portions too close together. It has been estimated that the average section of 640 acres within the optimum belt of the species will, if properly managed, yield 0.7 ton of medicinal bark annually, worth, according to quality and the season price scale, \$80 to \$200. The cut of bark on six national forests of Washington-Oregon over a period of 13 years has amounted to about 316 tons valued at over \$30,000. Vancouver is a chief port of shipment for cascara, an average of over 30 tons, valued at over \$6,200, being exported therefrom annually. Munger (*Journal of Forestry* 17(5): 605-607. 1919) reports that in the Northwest cascara-bark collection is essentially a home industry for spring, when the bark peels readily, and that for many Coast Range settlers it is the chief source of ready cash during the first years of land clearing.

The forest lands of the United States produce an enormous wealth of edible nuts and seeds. For example, the pecan crop of the United States, according to the 1929 census figures, was derived from about 5½ million wild and cultivated trees of bearing age, which produced 26,150,546 pounds of nuts whose value, at the conservative retail figure of 20 cents a pound, was \$5,230,109. Over half the bearing

trees are wild, chiefly occurring on privately owned land; the cultivated trees, of course, produce the higher-priced grades of nuts. The piñon industry is confined to the Southwest, from western Texas to central Utah and southeastern California. The juniper-piñon type covers approximately 100 million acres, largely owned by the Federal Government. The harvest is uncertain because of the prolonged periods of drought to which the Southwest is subject, good seed years being attendant upon a proper amount of rainfall. In 1925, a good seed year, 1,200,000 pounds of shelled piñon nuts were shipped out of New Mexico alone, according to available Forest Service records. The gathering of piñon nuts is an important seasonal job for certain residents, especially the native Mexican and Indian population.

Edible wild fruits are another important byproduct of the forest. Wild blueberry picking, for example, is on a commercial basis in several regions of the country, notably New England, parts of the Middle Atlantic States, the Blue Ridge region of Virginia, and parts of Montana, Washington, and Oregon. Over 30 species of the blueberry genus, most of them widely distributed, occur on the forest lands of the country, more especially in the North and Northeast, the mountainous districts of the South, the Rocky Mountain region, and the Pacific Northwest. Five species of the related huckleberry genus are native in the wooded regions (mostly privately owned) of the Eastern States. Western species of blueberry occur chiefly on Federal, railroad, and State lands. Accurate figures as to the extent of the blueberry-huckleberry industry are lacking, but it furnishes seasonal employment to thousands of people, and many thousands of boxes of fruit are picked annually for table use and the canning trade.

Where it is abundant within its range, southwestern Oregon to central California, the Pacific plum is an important element in local economy; when its excellent fruit ripens in summer other local work is often suspended and it is one of the most important food plants among certain Indian tribes, especially the Klamath Indians.

Accurate figures are largely lacking for values involved in the forest ornamental plant industry. There are enormous numbers of ornamental plants in the wooded sections of the country, many of which now enter the horticultural trade; doubtless many more will ultimately do so. Rhododendrons, azaleas, mountain laurel, and other ericaceous plants are shipped out annually, by the carload, from the mountain forests of North Carolina and other southern States, and the total area of acid soils in the wooded districts of the East where these species occur is probably in excess of 15,000,000 acres, probably the larger part of which is privately owned. The latest figures available, which are for the calendar year 1931 and represent fairly average conditions, show that 17,110 leucothoe plants were removed for horticultural use, under permit at a nominal sum, from the Unaka National Forest, Tenn., while 37,547 other ornamental shrubs (chiefly rhododendron and mountain laurel), priced at \$3,434.41, were sold under permit from three Appalachian national forests, the Pisgah, Monongahela, and Unaka. Removal of rhododendron and mountain laurel, where dense, assists in the establishment of timber reproduction, and clear-cutting or severe burning of timber in bottomlands tends to favor occupancy

of such sites by rhododendron. On the other hand, removal of these species from the forest on a large commercial scale has in some cases resulted in local extermination of rhododendron and other ornamental shrubs of the heath family. Extermination (rather than thinning) of these species is objectionable, especially along and near highways, not only on account of their pecuniary value, but because they greatly enhance the beauty of the woods and when in bloom attract large numbers of visitors. In fact, for some mountain communities these shrubs are an important advertising asset, helping to bring in a seasonal tourist trade which is a vital source of local income.

The Christmas-tree industry is a very large one, the annual consumption in the United States being estimated at about 10,000,000 trees, which, at the very conservative retail figure of 50 cents per tree, would amount to at least \$5,000,000 a year. No other country in the world has such a wealth of native conifers as the United States, and there are possibilities as yet undeveloped in the Christmas-tree trade both as a private business and from a public forest management standpoint. The Christmas-tree business, when properly conducted, involves a selective yearly thinning of the stand with a continuous annual supply as the objective. As conducted on the Pike National Forest in Colorado it largely represents a much-needed thinning of young Douglas fir stands, the reproduction of which ordinarily tends to be thicker than is desirable. The city of Denver, Colo., annually consumes about 40,000 Christmas trees plus 500 tons of boughs (for wreaths and other decorations) cut under permit from the Pike Forest, an operation involving a thinning of about 200 to 400 acres of forest annually. Prior to Forest Service management local Christmas-tree demand in Denver was largely met by promiscuous and destructive cutting on private lands, unsightly lopping of trees along mountain highways, and similar acts of vandalism. Such undesirable practices still largely obtain in many localities where forest management has not been brought to bear on the problem. In the East, one Pennsylvania farmer, on 1,500 acres of woodland, has annually averaged \$5,400 net over a 7-year period from the sale of Christmas trees, handling his crop on a selective-cutting basis.

The pre-Christmas season makes a wide-spread demand for labor to cut and handle not only Christmas trees but a great diversity of evergreens for wreaths and other decorative purposes, nearly all of which are obtained from the forest: Conifers, lycopods, and club-mosses from nearly all parts of the country, mistletoe from the South and the South Central States, holly and kalmia in the Eastern States, toyon, Oregon-grape, and salal from the Pacific States, and so on. As mistletoe is a destructive parasite of timber species its harvesting for decorative purposes is a positive benefit to the forest and is worthy of encouragement. Unfortunately, however, only one of the two native mistletoe genera possesses ornamental values.

Coville (U.S. Dept. Agr. Farmers' Bul. 1693) reports that the coastal portions of Delaware and Maryland are the present center of production for American holly greens and that this center is definitely moving southward. He states that in Maryland, during 1930 and 1931, local retailers paid approximately 15, 25, and 55 cents apiece for 10-, 15-, and 24-inch wreaths, respectively, and that bulk holly, in

standard-size boxes (2 by 2 by 4 feet) brought pickers about \$2 per box. District Forester Seigworth, of the Maryland Department of Forestry, estimates that, on the average, 10,000 persons (including many entire families) in the eight counties on the Eastern Shore of Maryland engage yearly in harvesting holly, from which they obtain an annual income of \$150,000. About 10,000 boxes are shipped annually. The Delaware Commission for the Conservation of Forests reported in 1927 that the holly-products industry of that State amounts to an average annual shipment of about 7,600 cases, valued at about \$400,000 and consisting of 1,500,000 wreaths besides loose sprays and branches. The crop is harvested chiefly by local farmers who receive about \$100,000 for their labor.

As already intimated, these miscellaneous forest byproducts have many valuable sociological relations. They furnish seasonal and local employment to numerous persons in the wooded portions of the country. The tapping and rendering of maple sap comes in late winter and early spring. Cascara peeling is largely a spring occupation. In North Carolina, especially in the region surrounding Marion, the collection of galax leaves furnishes employment to a great number of local people between November and March. Expert pickers, it is reported, gather about 10,000 leaves a day, for which they receive in the neighborhood of \$5. The pre-Christmas season makes a country-wide demand for ornamental forest evergreens. All these sources of seasonal local employment bring in cash returns or obviate expenditures as in the case of individual fuel supply, foods, etc., and render possible not only the maintenance of better standards of living but also in many cases the actual existence of communities in forested areas and elsewhere which otherwise could not survive.

The forest produces a great variety and amount of food available for human consumption and, even at this date, numerous Indian tribes are largely dependent upon the forest for subsistence. This vegetable human food of the forest consists of a wealth of wild fruits, edible seeds and nuts, bulbs, tubers, and farinaceous roots, succulent stalks, "greens", mushrooms and other edible fungi, etc.

The future possibilities of miscellaneous forest byproducts are exceedingly diversified and are of great importance. For example, an immense potential source of rubber supply is on hand in numerous native plants, largely of the forest, such as rabbitbrushes, pingues, goldenrods, sparges, cichoriaceae, etc., although much research will doubtless be needed to make rubber commercially available therefrom. There is an immense variety of indigenous forest medicinal plants, some of which are already in commercial use. A vast host of ornamental herbs, shrubs, and trees adorn the American forests, and largely affect their aesthetic appeal; these are becoming of increasing importance in the American horticultural trade.

There are desirable fiber-producing plants such as yuccas and dogbanes; lacquer and gum-producing species such as acacias and sumacs; outstanding honey plants, in extraordinary variety and abundance and often widely distributed, some of which (as in parts of California and the Southwest) are mainstays of the local honey industry; matting and basketry plants; dye plants; upholstery-stuffing material such as mosses and tillandsias; and products with numerous other uses, including yucca wood for splints, amole and

soapberry for soap, manzanita roots for pipe bowls, etc. Twenty-eight hundred pounds of moss (mostly sphagnum) was removed under permit during the calendar year 1931 from the White Mountain National Forest, N.H., and the Unaka National Forest, Tenn., chiefly for surgical dressings and horticultural packing.

No satisfactory inventory has yet been made of the extent and character of the minor products of American forests. For most of the species research is necessary to determine: (1) Their beneficial or detrimental relationship to the forest and to forest management, including timber, watershed, range, wild life, recreation, or other values; and (2) methods of utilization consistent with highest and perpetuated productivity and compatible with other outstanding forest uses and values.

Forests serve as natural laboratories for research. Their vegetation is proving to be an increasingly important source of supply for the plant breeder. Examples may be cited in the use of western forest species in the development of needed types of strawberry, of native aconite for the drug trade, of native forest grasses in the production of cultivated forage plants for range and pasture improvement at home and abroad, and in the breeding of plums. Important research is in progress on the role of the forest in harboring obnoxious plants, such as those that are poisonous, mechanically injurious, or which are abundant and worthless.

The proportion of forest plants known to be injurious to agriculture is relatively small; certain species serve as alternate hosts of timber and agricultural crop diseases, subjects which also require further study. For example, certain forest grasses serve as alternate hosts for cereal stripe rust, while barberries and buckthorns occupy similar roles for stem rust of spring wheat and crown rust of oats, respectively, and the thurberia bush harbors the cotton bollweevil. Further fields for study are indicated in the extent to which certain members of the forest cover shelter insects and other organisms injurious to man and beast, and the relationship borne to forest protection methods by various subsidiary plants, e.g., resinous shrubs such as snowbrush and bearmat, the inflammable spores of certain clubmosses, and certain fibrous tree lichens of the *alectoria*-*evernia* type. In the maple sugar sirup industry more information is needed as to the best number of tappable trees per acre, methods of obtaining the proper number per unit area of trees of the most desired "sugar orchard" type, the best diameter and depth of taphole, and, in general, methods and periods of tapping that will insure maximum continuous yield. Research is also needed regarding methods of collection, cutting, etc., of medicinal and ornamental plants conducive to permanent yield, and as to the use of bee-plant range at heights of flowering seasons of the most important plants.

The forest economics aspects of these minor by products need additional emphasis for, by their proper utilization, opportunity is afforded here and there to supplement income from forest properties to a greater or less extent.

Regulations needed for minor forest by products on Federal lands cover permits for sales and collection methods based upon use in conformity with the best management principles, and in recognition of the principle that the objective sought is permanent utilization and enjoyment of these byproducts, as opposed on the one hand to nonuse

and on the other to abuse, destruction, or other uneconomic management. However, further research is necessary to furnish the fundamental information on which the best management principles for these minor forest byproducts must be based. Maryland, California, and a few other States have enacted (largely on the initiative of the Wild Flower Preservation Society and other conservation agencies) laws and regulations to protect and perpetuate outstanding ornamental species of the forest, such as dogwood, trailing-arbutus, kalmia, orchids, toyon, etc. Additional legislation of this sort is doubtless desirable for other species and in other places to prevent extermination or decimation of aesthetic, rare, or otherwise valuable or interesting forest plants. Some communities and States have laws and regulations for eradication or control of obnoxious agricultural and highway plants, such as ragweed and puncturevine, and there is probably a field for similar legislation in certain localities with respect to obnoxious forest species.

A FOREST RANGE PROGRAM

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The "Forest Ranges" section of this report points out that 334 million acres, or 54 percent, of the forest land in the United States is used for grazing domestic livestock, and presents the problems involved in coordinating the use of forage with conservation and use of other forest resources. The need for management that will assure sustained yield of forest ranges is shown by the poor condition of much of the forest-range area of the West, the extreme and continuing deterioration of forage and watershed-protective values on most public-domain forest lands and on a considerable part of the private forest lands in the West that are grazed, the damage to timber production in the South resulting from uncontrolled burning of forest lands in an effort to improve range conditions, and the deterioration of some farm woodlands as a result of heavy browsing of tree sprouts. The management of these lands should be such as to perpetuate their range and other values, to afford sustained use of the forage by livestock, and to effect the economic and social benefits that would result from stabilizing the use of the lands. Sustained yield management of forest ranges involves: (1) Correlation of the use of the lands by domestic livestock with the conservation and use of other resources such as watershed protection, timber, recreation, and wild life; (2) reservation, consolidation, and administration of public lands now inadequately managed; (3) public acquisition for administration of certain areas at present in private ownership; and (4) research to develop principles of management.

The forest range management program deals with three distinct situations, those of the western forest ranges, the southern forest ranges, and the farm woodlands.

WESTERN FOREST RANGES

Public interests are vitally affected by the management of forest ranges in the West. The present productivity of the herbaceous and shrubby vegetation, falling far short of the potential productivity on many areas, does not furnish as satisfactory livestock production as possible, and thus limits the prosperity of the livestock industry

and communities dependent upon it. Watershed-protective values of grazed forest ranges would be improved by increased vegetative cover. On some areas overgrazing or other improper grazing use is impairing the perpetuation of timber and wild-life resources.

THE UNRESERVED PUBLIC DOMAIN

Outstanding among the problems presented by the 102 million acres of publicly owned or managed forest range land in the West are those that have arisen on the public domain, as a result of use without administration. Grazed lands make up 21.5 million acres of the 23 million acres of forest land now remaining in the public domain. There is urgent need for legislation placing these lands under a type of administration that will stop abuse, restore values, and stabilize grazing use for local community and other public benefit. As is shown in the "Other Federal Forest Land" section of this report, approximately 19 million acres of the public domain, including 11.5 million acres of forested land, should be added to the national forests. About 3 million acres additional, of which 1.5 million acres is forest land, should be given national-forest status and held for inclusion in new administrative units as these are built up by acquisition or exchange. The remaining public domain, including approximately 10 million acres of forested land, should be placed under Federal administration that will assure satisfactory management.

STATE FOREST RANGES

On most State-owned forest ranges, other than those that are now handled under cooperative agreement with the Forest Service, better coordination of grazing with other forest uses is necessary. This would best be effected by consolidating as much as possible of the 4 million acres of grazed forest lands in State ownership into State forests or other administrative units with a legal status insuring sustained-yield management. On forested State lands that cannot effectively be grouped into administrative units, it is essential that leases include specifications as to numbers of stock to be admitted, seasons of use, and other phases of management, and that field supervision be provided, in order to prevent overgrazing and assure range restoration where it is needed.

PRIVATE FOREST RANGES

Of the 64 million acres of private forest land in the West approximately 42 million acres is grazed. On a high percentage of this area the effort to gain the maximum current income has been carried to an extreme without adequate safeguards for permanent stability of the range resource. This has resulted in range depletion that not only adversely affects the individual stockman but also is doing damage to others, especially through impairing watershed-protective values. Where it is demonstrated to stockmen using these private lands that by modifying their present practices they can correct existing damage to forest range resources without material loss of revenue or with an eventual increase in revenue, better management of the ranges can reasonably be expected. Western agricultural extension services could very well give a greater place on their educational and demonstrational programs to improved principles of range management.

In the case of critical areas, public ownership and management will probably be the only effective solution. In the section of this report entitled "The Probable Future Distribution of Forest Land Ownership", it is recommended that 41 million acres of forest land in the West having a major watershed-protection influence be purchased or otherwise acquired from private owners and administered by public agencies to assure satisfactory watershed protection. Probably two thirds of this area proposed for public acquisition is grazed.

A small additional area of private forest range land should be acquired by the public by purchase or exchange in order to consolidate existing units of publicly owned land and thus facilitate their proper management.

EXISTING FEDERAL RESERVATIONS

About 64 million acres, or nearly two thirds, of the publicly owned or managed forest range lands in the West is within the national forests. The administrative aim on the national forests, of obtaining as fully beneficial use of the various resources of the land as is consistent with their permanent conservation, has resulted, on the average, in a marked improvement of forage conditions. This in turn has tended to stabilize livestock production on national forests and to furnish an improvement in watershed-protective values and in conditions favorable for wild life. Such administration should be continued and management should be improved as research results and more accurate information concerning the grazing resource become available. Development of range improvements such as fences and watering places should progress steadily. About 90 percent of the 900,000 acres of western forest land recommended for artificial revegetation in the section of this report entitled "A Watershed Protection Program" is within the national forests. In addition to this area on which artificial reseeding could be applied on the basis of present knowledge, there are very large acreages within the national forests and elsewhere, particularly at the lower elevations, on which artificial reseeding is desirable but will require further research.

Within the Indian reservations, on which the aim is to obtain maximum benefit for the Indians, there is need for an intensification of field administration and management, as outlined by Muck, Melis, and Nyce,¹ with special emphasis upon sustained forage production and effective protection of forest-land resources.

The area of grazed forest land in other Federal reservations is relatively small. On most of it, grazing is administered in such a manner as to have the least possible influence on the major use of the area. Within the national parks, for example, grazing, where still permitted, is subordinated to recreational and inspirational values.

SOUTHERN FOREST RANGES

In the South the forest range problem at the present time is almost entirely restricted to privately owned land; nearly 98 percent of the southern forest area grazed by domestic livestock is in private ownership. As public agencies continue to acquire forest land, administra-

¹ Muck, Lee, Melis, P. E., and Nyce, G. M. An Economic Survey of the Range Resources and Grazing Activities on Indian Reservations. Hearings before a Subcommittee of the Committee on Indian Affairs, United States Senate, Seventy-first Congress, Second Session. S.Res. 79, 308 (70th Cong.), and S.Res. 263 and 416 (71st Cong.), 1932.

tion of public lands will become more prominent. A program that will safeguard timber and other forest values and aid in livestock production includes: (1) Control of fire; (2) control of grazing by hogs, especially in the longleaf pine belt; and (3) coordination of forest range use with use of improved pastures and of forage crops on farms.

This program would be advanced by ultimate Federal acquisition of about 78 million acres and State acquisition of 19½ million acres of private land in the South for timber production and watershed protection, recommended in the section of this report entitled "The Probable Future Distribution of Forest Land Ownership." In many of the southern States legislative provision would be necessary for the organization of these lands into State forests and for their administration and management. On forest land remaining in private ownership, education and demonstration will be the principal means of correcting practices detrimental to timber production and obtaining coordination of the use of forest lands with that of agricultural lands to assure the most beneficial use of all the feed resources. In some States, for satisfactory timber production, legislation may be required to prevent trespass on large private forest holdings.

FARM WOODLANDS

The greater portion of the grazed farm woodlands in the Central States, Lake States, Middle Atlantic, and New England regions will remain in private ownership. In these regions the individual owner should decide what is the most profitable use of his farm woodland and, accordingly either exclude livestock, admit livestock to a small portion of the woodland for shade but exclude it from the remainder, or admit livestock to the area only for such a period and in such numbers as will permit sustained yield of timber and forage. Safeguarding forest regeneration and other forest values will require research and education.

In these regions grazing on public forest lands is ordinarily light. It is probable that grazing use will be light on many of the forest areas acquired by public agencies for watershed protection or timber production. Feed resources on farm land are so abundant and grazing values on forest lands so low that use of public forest land by domestic livestock should be restricted to such areas as can be grazed without detriment to other forest values.

RESEARCH

Experience and the comparatively small amount of research done to date have developed many improved practices in the use of forest range lands, which make for greater stability in use and for increased revenues to offset any increase in production costs resulting from increased settlement, range deterioration, and more intensive management. Much still needs to be learned with respect to coordinating the use of forest range forage with the conservation and use of other resources and with respect to utilizing the important forage plants in a manner that avoids danger of deterioration and tends to improve depleted forage cover.

In plans for research bearing on the management of forest range lands, emphasis should be placed on breaking down the broader problems of plant succession, soil productivity, physiological response

to use, genetic development of range plants, biological relationships, etc., into factors that can be studied and evaluated in an exact way. In order to meet current problems of management, the more immediately practical studies, which have largely characterized the work to date, should be continued. Studies of forest range restoration should consider both the possibilities of restoring and maintaining the stand of native forage plants and the possibilities of artificially reseeding areas where natural restoration of native plants would require a very long period. Many economic phases of use of forest ranges and of profitable production of livestock on such ranges will need to be studied intensively and continuously if ever-changing economic conditions are to be met.

A considerable expansion of the range-research program of Federal and State agencies is well warranted. In the section of this report entitled "Research in the United States Forest Service, a Study in Objectives", a 10-year program for financing research is set up, including the last four years (1935-38 inclusive) of the decade provided for originally by the McSweeney-McNary Act and an additional six years ending with the fiscal year 1944. This 10-year program recommends that appropriations for the range investigations of the Forest Service be increased by an average of \$40,000 a year up to 1938, in order to meet the McSweeney-McNary Act authorizations of \$275,000 yearly. For the period 1939 to 1944, inclusive, it recommends annual increases averaging \$50,000. There is not much doubt that at the end of this 10-year period there will still be need to expand the research program.

